

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	TITLE	i
	DECLARATION	ii
	ACKNOWLEDGEMENTS	iii
	ABSTRACT	iv
	ABSTRAK	v
	TABLE OF CONTENTS	vi
	LIST OF TABLES	xi
	LIST OF FIGURES	xiv
	LIST OF SYMBOLS	xxii
	LIST OF APPENDICES	xxiii
1	INTRODUCTION	1
1.1	General	1
1.2	Background of the Problem	2
1.3	Problem Statement	3
1.4	Objectives of the Study	4
1.5	Scope of the Study	5
1.6	Significance of Research	6
1.7	Thesis Structure	8

2	LITERATURE REVIEW	10
2.1	Introduction	10
2.2	Submerged Breakwaters	10
2.2.1	Artificial Reef Breakwaters	11
2.2.2	Geotextile Tube Breakwaters	13
2.3	Submerged Perforated Pile Breakwaters	14
2.4	Theoretical Concepts in Wave - Submerged Perforated Breakwater Interaction	20
2.4.1	Wave Transmission	20
2.4.2	Wave Reflection	21
2.4.3	Wave Energy Dissipation	22
2.5	Physical Process in Wave - Submerged Perforated Breakwater Interaction	24
2.5.1	Characteristics of Wave – Structure Interaction	24
2.5.2	Reviews on Submerged Perforated Breakwater Performance	25
2.5.3	Parameters Affecting Wave Transmission	29
2.5.3.1	Wave Steepness, H_i/L	29
2.5.3.2	Water Depth, h	32
2.5.3.3	Porosity, ε	35
2.6	Analytical Study	39
3	EXPERIMENTAL SET-UP AND PROCEDURES	40
3.1	Introduction	40
3.2	Wave Flume	42
3.3	Wave Generation	43
3.4	Wave Probes and Data Acquisition System	44
3.5	Wave Probe Calibration	47
3.6	Experiments to Estimate Incident and Reflected Waves	49
3.7	Determination of Wave Period and Wave Length	55
3.8	Experimental Test Models	60
3.8.1	The Single Ring Pile (SP) Test Model	60
3.8.2	The Double Ring Pile (DP) Test Model	62
3.8.3	The Single Ring Small Pile (SSP) Test Model	64

3.9	Data Processing	65
3.10	Experimental Limitation	65
4	EXPERIMENTAL RESULTS AND ANALYSIS	67
4.1	Introduction	67
4.2	Dimensional Analysis	67
4.3	Experimental Results and Analysis	72
4.3.1	The One-row Single Ring Pile (SP) Test Model	72
4.3.1.1	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Transmission (K_t)	73
4.3.1.2	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Energy Losses (K_l)	76
4.3.2	The One-row Double Ring Pile (DP) Test Model	78
4.3.2.1	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Transmission (K_t)	78
4.3.2.2	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Energy Losses (K_l)	81
4.3.3	The One-row Single Ring Small Pile (SSP) Test Model	83
4.3.3.1	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Transmission (K_t)	83
4.3.3.2	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Energy Losses (K_l)	85
4.3.4	Summary of the One-row Test Model	87
4.3.5	The Two-row Single Ring Pile (SP) Test Model	88
4.3.5.1	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Transmission (K_t)	89
4.3.5.2	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Energy Losses (K_l)	94
4.3.6	The Two-row Double Ring Pile (DP) Test Model	99

4.3.6.1	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Transmission (K_t)	99
4.3.6.2	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Energy Losses (K_l)	105
4.3.7	Summary of the Two-row Test Model	110
4.3.8	The Two-row DP Model: Other Influences	111
4.3.8.1	The Influence of Relative Spacing (B/L), Porosity (ε) and Water Depth (h) on Wave Transmission (K_t)	111
4.3.8.2	The Influence of Relative Spacing (B/L), Porosity (ε) and Water Depth (h) on Wave Energy Losses (K_l)	114
4.3.8.3	The Influence of Relative Width (W/L), Porosity (ε) and Water Depth (h) on Wave Transmission (K_t)	116
4.3.8.4	The Influence of Relative Width (W/L), Porosity (ε) and Water Depth (h) on Wave Energy Losses (K_l)	119
4.3.9	The Three-row Double Ring Pile (DP) Test Model	121
4.3.9.1	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Transmission (K_t)	122
4.3.9.2	The Influence of Wave Steepness (H_i/L), Porosity (ε) and Water Depth (h) on Wave Energy Losses (K_l)	126
4.3.10	Summary of the DP Test Models	131
5	DERIVATION OF ANALYTICAL EXPRESSION FOR WAVE TRANSMISSION	132
5.1	Introduction	132
5.2	Comparison of Wave Transmission Coefficient with Values obtained from Other Research Works	132
5.3	Derivation of Analytical Functions for Wave Transmission Coefficient of DP Model	133
5.3.1	Least Squares Regression Analysis	134
5.4	Multiple Linear Regression Analysis for the Double Ring Pile Test Models	135
5.4.1	Evaluation of the Variables	137

5.4.2	Development of Empirical Expression for Wave Transmission Coefficient (K_t) and Wave Energy Losses (K_l)	141
5.4.2.1	Coefficient of Wave Transmission, K_t	141
5.4.2.2	Wave Energy Losses, K_l	146
5.5	Multiple Regression Diagnostics	148
5.5.1	The One-row DP Model	148
5.5.2	The Two-row DP Model	152
5.5.2.1	Without Spacing	152
5.5.2.2	With Spacing	153
6	CONCLUSIONS AND RECOMMENDATIONS	156
6.1	Conclusions	156
6.2	Recommendations	159
	REFERENCES	161
	Appendices A – H	169

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	A Summary of Previous Studies on the Performance of Various Type of Submerged Breakwaters As Wave Energy Dissipators.	27
2.2	An Illustration of the Types of Shapes of Previous Submerged Breakwaters as Wave Energy Dissipators.	28
3.1	Mean Values of Voltage for Various Still Water Levels	48
3.2	Mean Wave Period for Various Frequencies of Wave Generating Motor	57
3.3	Determination of Wave Number, k by the Bi-Section Method	58
3.4	Determination of Wave Length Using Linear Dispersion Relationship	59
3.5	Dimensions of Test Models and Wave Characteristics	61
4.1	Variables Influencing Wave Transmission	70
4.2	Summary of Results: K_t versus H_i/L for the One-row SP Models	75
4.3	Summary of Results: K_t versus H_i/L for the One-row SP Models	78
4.4	Summary of Results: K_t versus H_i/L for the One-row DP Models	80
4.5	Summary of Results: K_t versus H_i/L for the One-row DP Models	82
4.6	Summary of Results: K_t versus H_i/L for the One-row SSP Models	85

4.7	Summary of Results: K_I versus H_i/L for the One-row SSP Models	87
4.8	Summary of Results: K_I versus H_i/L for the Two-row SP Models at $B/D = 0$	93
4.9	Summary of Results: K_I versus H_i/L for the Two-row SP Models at $B/D = 0.5$	93
4.10	Summary of Results: K_I versus H_i/L for the Two-row SP Models at $B/D = 0.75$	94
4.11	Summary of Results: K_I versus H_i/L for the Two-row SP Models at $B/D = 0$	98
4.12	Summary of Results: K_I versus H_i/L for the Two-row SP Models at $B/D = 0.5$	98
4.13	Summary of Results: K_I versus H_i/L for the Two-row SP Models at $B/D = 0.75$	99
4.14	Summary of Results: K_I versus H_i/L for the Two-row DP Models at $B/D = 0$	103
4.15	Summary of Results: K_I versus H_i/L for the Two-row DP Models at $B/D = 0.5$	104
4.16	Summary of Results: K_I versus H_i/L for the Two-row DP Models at $B/D = 0.75$	104
4.17	Summary of Results: K_I versus H_i/L for the Two-row DP Models at $B/D = 0$	108
4.18	Summary of Results: K_I versus H_i/L for the Two-row DP Models at $B/D = 0.5$	109
4.19	Summary of Results: K_I versus H_i/L for the Two-row DP Models at $B/D = 0.75$	109
4.20	Summary of Results: K_I versus H_i/L for the Three-row DP Models at $B/D = 0$	125
4.21	Summary of Results: K_I versus H_i/L for the Three-row DP Models at $B/D = 0.5$	126

4.22	Summary of Results: K_t versus H_i/L for the Three-row DP Models at $B/D = 0.75$	126
4.23	Summary of Results: K_t versus H_i/L for the Three-row DP Models at $B/D = 0$	130
4.24	Summary of Results: K_t versus H_i/L for the Three-row DP Models at $B/D = 0.5$	130
4.25	Summary of Results: K_t versus H_i/L for the Three-row DP Models at $B/D = 0.75$	131
5.1	Range of Independent Variables for the One-row and Two-row DP Models in Partially Submerged Set-up	138
5.2	Range of Independent Variables for the One-row and Two-row DP Models in Fully Submerged Set-up	139
5.3	Comparison between the Predicted and Measured K_t Values for the One-row DP Model Under Partially Submerged Set-up	150
6.1	Summary of Equations Derived for the DP Models Under Partially Submerged Condition	158
6.2	Summary of Equations Derived for the DP Models Under Fully Submerged Condition	159

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1(a)	Manufactured Concrete Breakwater Blocks (Source: Mottet, 1985)	6
1.1(b)	Manufactured Concrete Breakwater Blocks (Source: Mottet, 1985)	7
1.2	Smooth-shaped Reefs (Source: Mottet, 1985 and Reefball Development Group, 1997)	7
2.1	Individual Reef Ball™ Unit (Source: Reef Ball Development Group, 1997)	11
2.2	Three-Row Submerged Breakwater (Source: Harris, 2003)	12
2.3	Increased Beach Width 1998 to 2001 at Center of Dominican Southern Shore – Looking West (Source: Harris, 2003)	12
2.4	A Typical Submerged Geotextile Tube (Source: Oh and Shin, 2006)	13
2.5	Schematic Diagram for Installing Geotextile Tube at Young-Jin Beach (Source: Oh and Shin, 2006)	14
2.6	Definition Sketch and Details of Two-row Perforated Piles (Source: Rao <i>et al</i> , 1999)	15
2.7	Definition and Details of Perforated Pipes (Source: Rao <i>et al</i> , 2003)	16
2.8	Influence of Depth of Submergence, y/h on Loss Coefficient, K_1 (Source : Rao <i>et al</i> , 2003)	16
2.9	Example of a 3-filter system (Source: Clauss and Habel, 1999)	17

2.10	Energy of Transmission, Reflection and Dissipation for Different Filter System (Source: Clauss and Habel, 1999)	18
2.11	Example of Experimental Setup for Frame-type Rectangular Wooden Model (Source: Ting <i>et al</i> , 2004)	19
2.12	Definition Sketch: (a) Side View (b) Front View (Source: Suh <i>et al</i> , 2005)	19
2.13	Wave Structure Interactions at a Submerged Breakwater	24
2.14	K_t vs. H_i/L for One-row Non-perforated Pile Breakwater (Source: Herbich and Douglas, 1988)	30
2.15	K_t vs. H_i/L for One-row Non-perforated Pile Breakwater (Source: Rao <i>et al</i> , 1999)	30
2.16	K_t vs. H_i/L for Submerged Frame-like Breakwater (Source: Ting <i>et al</i> , 2004)	31
2.17	K_t vs. h/L for One and Two-row of Piles (Source: Herbich and Douglas, 1988)	33
2.18	Comparison between Two-row of Piles and a Wave Screen (Source: Herbich and Douglas, 1988)	33
2.19	Wave Transmission under Various Water Depths (Source: Armono and Hall, 2000)	34
2.20	Notation used for the Calculation of Porosity	35
2.21	K_t vs. ε (Source: Grüne and Kohlhasse, 1974)	36
3.1	Research Methodology Framework	41
3.2	Schematic Layout of the Wave Flume	42
3.3	Wave Maker and Controller	44
3.4	Wave Probe Distance to Test Model	46

3.5	Wave Data Acquisition	46
3.6	Water Level (m) vs. Voltage (V)	48
3.7	Wave Probe Spacing	51
3.8	Relationship between Wave Period and Frequency of Generating System	58
3.9	Relative Water Depth vs. Wave Period for $h = 0.19$ m to $h = 0.35$ m	59
3.10	Various Porosities, ε of Single Ring Pile (SP)	61
3.11	Plan View of the SP Model Arrangements Used in the Experiment	62
3.12	Illustration of Model Spacing (B) and Model Width (W)	62
3.13	Various Porosities, ε of Double Ring Pile (DP)	63
3.14	Plan View of the DP Model Arrangements Used in the Experiment	63
3.15	A Sketch of the Double Ring Pile (DP) Test Model	64
3.16	Various Porosities, ε of Single Ring Small Pile (SSP)	64
3.17	Plan View of the SSP Model Arrangements Used in the Experiment	65
4.1	Summary of Experimental Workflow	69
4.2	Variables Influencing Wave Transmission in Test Models	70
4.3	K_t vs. H_i/L for the Partially Submerged One-row SP	73
4.4	K_t vs. H_i/L for the Fully Submerged One-row SP	74
4.5	K_l vs. H_i/L for the Partially Submerged One-row SP	77
4.6	K_l vs. H_i/L for the Fully Submerged One-row SP	77

4.7	K_t vs. H_i/L for the Partially Submerged One-row DP	79
4.8	K_t vs. H_i/L for the Fully Submerged One-row DP	80
4.9	K_l vs. H_i/L for the Partially Submerged One-row DP	81
4.10	K_l vs. H_i/L for the Fully Submerged One-row DP	82
4.11	K_t vs. H_i/L for the Partially Submerged One-row SSP	84
4.12	K_t vs. H_i/L for the Fully Submerged One-row SSP	84
4.13	K_l vs. H_i/L for the Partially Submerged One-row SSP	86
4.14	K_l vs. H_i/L for the Fully Submerged One-row SSP	86
4.15	Comparison of Results for One-row Various Test Models at $h = 0.23$ m, $\varepsilon = 0.48$; (a) K_r vs. h/L (b) K_t vs. h/L (c) K_l vs. h/L	88
4.16	K_t vs. H_i/L for the Partially Submerged Two-row SP ($B/D = 0$)	89
4.17	K_t vs. H_i/L for the Partially Submerged Two-row SP ($B/D = 0.5$)	90
4.18	K_t vs. H_i/L for the Partially Submerged Two-row SP ($B/D = 0.75$)	90
4.19	K_t vs. H_i/L for the Fully Submerged Two-row SP ($B/D = 0$)	91
4.20	K_t vs. H_i/L for the Fully Submerged Two-row SP ($B/D = 0.5$)	91
4.21	K_t vs. H_i/L for the Fully Submerged Two-row SP ($B/D = 0.75$)	92
4.22	K_l vs. H_i/L for the Partially Submerged Two-row SP ($B/D = 0$)	95
4.23	K_l vs. H_i/L for the Partially Submerged Two-row SP ($B/D = 0.5$)	95

4.24	K_l vs. H_i/L for the Partially Submerged Two-row SP ($B/D = 0.75$)	96
4.25	K_l vs. H_i/L for the Fully Submerged Two-row SP ($B/D = 0$)	96
4.26	K_l vs. H_i/L for the Fully Submerged Two-row SP ($B/D = 0.5$)	97
4.27	K_l vs. H_i/L for the Fully Submerged Two-row SP ($B/D = 0.75$)	97
4.28	K_t vs. H_i/L for the Partially Submerged Two-row DP ($B/D = 0$)	100
4.29	K_t vs. H_i/L for the Partially Submerged Two-row DP ($B/D = 0.5$)	101
4.30	K_t vs. H_i/L for the Partially Submerged Two-row DP ($B/D = 0.75$)	101
4.31	K_t vs. H_i/L for the Fully Submerged Two-row DP ($B/D = 0$)	102
4.32	K_t vs. H_i/L for the Fully Submerged Two-row DP ($B/D = 0.5$)	102
4.33	K_t vs. H_i/L for the Fully Submerged Two-row DP ($B/D = 0.75$)	103
4.34	K_l vs. H_i/L for the Partially Submerged Two-row DP ($B/D = 0$)	105
4.35	K_l vs. H_i/L for the Partially Submerged Two-row DP ($B/D = 0.5$)	106
4.36	K_l vs. H_i/L for the Partially Submerged Two-row DP ($B/D = 0.75$)	106
4.37	K_l vs. H_i/L for the Fully Submerged Two-row DP ($B/D = 0$)	107
4.38	K_l vs. H_i/L for the Fully Submerged Two-row DP ($B/D = 0.5$)	107

4.39	K_t vs. H_i/L for the Fully Submerged Two-row DP ($B/D = 0.75$)	108
4.40	K_t vs. H_i/L for Two-row SP and DP Models ($h = 0.23$ m; $\varepsilon = 0.48$; $B/D = 0$)	110
4.41	K_t vs. B/L for the Partially Submerged Two-row DP ($B = 0.5D$)	112
4.42	K_t vs. B/L for the Partially Submerged Two-row DP ($B = 0.75D$)	112
4.43	K_t vs. B/L for the Fully Submerged Two-row DP ($B = 0.5D$)	113
4.44	K_t vs. B/L for the Fully Submerged Two-row DP ($B = 0.75D$)	113
4.45	K_t vs. B/L for the Partially Submerged Two-row DP ($B/D = 0.5$)	114
4.46	K_t vs. B/L for the Partially Submerged Two-row DP ($B/D = 0.75$)	115
4.47	K_t vs. B/L for the Fully Submerged Two-row DP ($B/D = 0.5$)	115
4.48	K_t vs. B/L for the Fully Submerged Two-row DP ($B/D = 0.75$)	116
4.49	K_t vs. W/L for the Partially Submerged One-row DP	117
4.50	K_t vs. W/L for the Partially Submerged Two-row DP	117
4.51	K_t vs. W/L for the Fully Submerged One-row DP	118
4.52	K_t vs. W/L for the Fully Submerged Two-row DP	118
4.53	K_t vs. W/L for the Partially Submerged One-row DP	119
4.54	K_t vs. W/L for the Partially Submerged Two-row DP	120
4.55	K_t vs. W/L for the Fully Submerged One-row DP	120

4.56	K_l vs. W/L for the Fully Submerged Two -row DP	121
4.57	K_l vs. H_i/L for the Partially Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0$)	122
4.58	K_l vs. H_i/L for the Partially Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0.5$)	123
4.59	K_l vs. H_i/L for the Partially Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0.75$)	123
4.60	K_l vs. H_i/L for the Fully Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0$)	124
4.61	K_l vs. H_i/L for the Fully Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0.5$)	124
4.62	K_l vs. H_i/L for the Fully Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0.75$)	125
4.63	K_l vs. H_i/L for the Partially Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0$)	127
4.64	K_l vs. H_i/L for the Partially Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0.5$)	127
4.65	K_l vs. H_i/L for the Partially Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0.75$)	128
4.66	K_l vs. H_i/L for the Fully Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0$)	128
4.67	K_l vs. H_i/L for the Fully Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0.5$)	129
4.68	K_l vs. H_i/L for the Fully Submerged Three-row DP ($\varepsilon = 0.48$, $B/D = 0.75$)	129
5.1	Comparison of Wave Transmission Coefficient from the Experimental Results with Values from Works by Other Researchers	133
5.2	K_l (predicted) vs. K_l (measured) for the One-row DP Model under Partially Submerged Set-up	149

5.3	K_t (predicted) vs. K_t (measured) for the One-row DP Model under Fully Submerged Set-up	149
5.4	K_t (predicted) vs. K_t (measured) for the Two-row DP Model Without Spacing under Partially Submerged Set-up	152
5.5	K_t (predicted) vs. K_t (measured) for the Two-row DP Model Without Spacing under Fully Submerged Set-up	153
5.6	K_t (predicted) vs. K_t (measured) for the Two-row DP Model With Spacing Using General Equation under Partially Submerged Set-up	154
5.7	K_t (predicted) vs. K_t (measured) for the Two-row DP Model With Spacing Using General Equation under Fully Submerged Set-up	154

LIST OF SYMBOLS

a_0, a_1, a_2	-	Constants for the Second Order Polynomial Curve Line
B	-	Spacing between the Pile Rows (mm)
D	-	Diameter of Internal Layer Pile (mm)
D'	-	Diameter of External Layer Pile (mm)
d	-	Diameter of Perforation (mm)
E_I	-	Incident Wave Energy
E_L	-	Energy Lost
E_R	-	Reflected Wave Energy
E_T	-	Transmitted Wave Energy
g	-	Gravitational Acceleration (= 9.81 m/s ²)
H_i	-	Incident Wave Height (m)
H_r	-	Reflected Wave Height (m)
H_t	-	Transmitted Wave Height (m)
h	-	Water Depth (m)
h'	-	Height of Structure (m)
h_s	-	Depth of submergence (m)
K_l	-	Coefficient of Loss
K_r	-	Coefficient of Reflection
K_t	-	Coefficient of Transmission
k	-	Wave Number
L	-	Wave Length (m)
T	-	Wave Period (s)
W	-	Structure Width (Two to Three Rows of Closely Spaced Pile) (m)
ρ	-	Fluid Density (kg/m ³)
ε	-	Porosity

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A1	MATLAB Programme for Analysing Experimental Results	169
B1	Scatter Plot Matrix of K_t and 4 Independent Variables for One-row DP Without Spacing	170
B2	Scatter Plot Matrix of K_t and 4 Independent Variables for Two-row DP Without Spacing	171
B3	Scatter Plot Matrix of K_t and 4 Independent Variables for Two-row DP With Spacing	172
C1	Results of the Multiple Linear Regression Analysis for the One-row DP Model under Partially Submerged Set-up	173
C2	Results of the Multiple Linear Regression Analysis for the One-row DP Model under Fully Submerged Set-up	174
D1	Results of the Multiple Linear Regression Analysis for the Two-row DP Model Without Spacing under Partially Submerged Set-up	175
D2	Results of the Multiple Linear Regression Analysis for the Two-row DP Model Without Spacing under Fully Submerged Set-up	176
E1	Results of the Multiple Linear Regression Analysis for the Two-row DP Model With Spacing under Partially Submerged Set-up	177
E2	Results of the Multiple Linear Regression Analysis for the Two-row DP Model With Spacing under Fully Submerged Set-up	178

F1	Comparison between the Measured and Predicted K_t Values for the One-row DP Model under Fully Submerged Set-up	179
G1	Comparison between the Measured and Predicted K_t Values for the Two-row DP Model Without Spacing under Partially Submerged Set-up	182
G2	Comparison between the Measured and Predicted K_t Values for the Two-row DP Model Without Spacing under Fully Submerged Set-up	184
H1	Comparison between the Measured and Predicted K_t Values for the Two-row DP Model With Spacing Using General Equation under Partially Submerged Set-up	187
H2	Comparison between the Measured and Predicted K_t Values for the Two-row DP Model With Spacing Using General Equation under Fully Submerged Set-up	190